CRITFC

TECHNICAL REPORT 14-04

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AGE AND LENGTH COMPOSITION OF COLUMBIA BASIN CHINOOK AND SOCKEYE SALMON AND STEELHEAD AT BONNEVILLE DAM IN 2013

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Columbia River Inter-Tribal Fish Commission
Technical Report
for the
Department of Interior
Contract No. CTPOOX90106

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ABSTRACT

The Columbia River Inter-Tribal Fish Commission (CRITFC) conducts a field study at Bonneville Dam which first began in 1985 to assess the age, length-at-age, and stock composition of adult Pacific salmon migrating up the Columbia River. Adult spring, summer, and fall Chinook salmon (Oncorhynchus tshawytscha), sockeye salmon (O. nerka), and steelhead (O. mykiss) were collected, sampled for scales and additional biological data, PIT tagged, revived and released. Caudal fin clips were also taken from Chinook, steelhead, and sockeye for genetic analysis. Scales were examined to estimate age composition; the results contributed to an ongoing database for age structure of Columbia Basin salmon runs. Based on scale pattern analysis of our sample, four-year-olds were the most abundant age group for spring and summer Chinook salmon comprising, respectively, 53.8% and 39.7% of the runs. Three-year-olds were the most abundant age class for the fall Chinook salmon making up 50.3% of the run. Four-year-olds were the most abundant age group for sockeye salmon comprising 63.2% of the run, and three-year-olds were the most abundant in the steelhead run comprising 43.9% of the run. Steelhead data were analyzed for the salt years regardless of the freshwater phase, the majority of steelhead had one-salt winters (70.6%) in 2013. Using adipose fin clips, scale patterns, and dorsal fin condition for classification, the steelhead migration consisted of 63.7% hatchery- and 36.3% natural-origin steelhead. A-run steelhead, less than 78cm in length, comprised 95.5% of the steelhead run. B-run fish, equal to or greater than 78cm, comprised 4.5% of the run.

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INTRODUCTION

In 1985, the US-Canada Pacific Salmon Treaty was signed to manage research and enhance Pacific salmon (PSC 2000). The treaty established the Spawning Escapement-Monitoring program to assess indicator stocks within the Columbia River Basin and improve methods for providing population estimates, escapement monitoring, establishing spawner-recruit relationships and developing harvest management approaches (PST 1985). As part of this program, the Columbia River Inter-Tribal Fish Commission (CRITFC) has developed a comprehensive research strategy to monitor the age and stock composition of adult Pacific salmon returning to the Columbia River. This project has monitored the above Bonneville Dam adult migration of sockeye salmon (Oncorhynchus nerka) since 1985, spring Chinook salmon (O. tshawytscha) since 1987, summer Chinook salmon since 1990, up-river bright fall Chinook salmon since 1998, and summer steelhead (O. mykiss) were added to our sampling regime in 2004. Data on these runs are provided in near real time at www.critfc.org.

Scale pattern analysis, the analysis of concentric rings or circuli to provide records of previous life history, is a common method for age determination in Pacific salmon (Nielsen and Johnson 1983). Fast summer growth widens the distances between circuli on the scale and slow winter growth shortens the distance between circuli. Typically, age can be determined by counting the number of winters observed on the scale (Gilbert 1912, Rich and Holmes 1928). This method is valuable in Pacific salmon management because scales can be collected without sacrificing the fish and scale samples can be collected, processed, and aged promptly. Problems with this method may include variability in scale growth, scale resorption, and difficulties in age validation (Knudsen 1990, Beamish and McFarlane 1983).

Scale pattern analysis can also be used for stock identification if distinctive patterns can be linked to specific stocks. This method has generally been successful in discriminating Columbia River sockeye partly because there are only two major runs of sockeye in the system, which experience dramatically different early rearing environments (Fryer 1995). However, this method was found to be less successful with Chinook salmon where numerous populations can exhibit similar scale growth patterns. Currently a coast wide genetic database is being developed to create baseline microsatellite and Single Nucleotide Polymorphism (SNP) genetic data for individual salmon and steelhead populations throughout the region. This baseline genetic stock information can be utilized in mixed stock sampling to distinguish individual stocks and will be useful for the sampling program at Bonneville Dam.

The primary objectives for the 2013 sampling year were to estimate the age composition and length-at-age composition of Chinook and sockeye salmon, and steelhead using scale pattern analysis, to forecast the future run size of Chinook salmon using the age composition data, to

PIT tag Chinook, sockeye, and steelhead and to collect tissue samples for use in the development of a genetic stock monitoring and identification program for Chinook and sockeye, and steelhead.

METHODS

Study Area

Research was conducted at Bonneville Dam (river km 235), which is first dam encountered by salmonids on their migration upriver to spawn (Figure 1). The collection of salmon and steelhead occurs at the Adult Fish Facility (AFF) located on the Washington shore immediately downstream of Bonneville Dam. This facility uses a picket weir to divert migrating fish, ascending the Washington shore fish ladder, into the adult sampling facility collection pool. An attraction flow is used to draw fish through a false weir where they can be selected for sampling. Fish not selected and fish that have recovered from sampling are returned to the Washington Shore Fish ladder above the picket weir.

Figure 1. Map of the Columbia River displaying federal dams. Bonneville Dam (Rkm 235).

Chinook salmon generally migrate between March and November and are typically categorized into three races based on migration timing past Bonneville Dam. Chinook salmon passing Bonneville before June 1 are classified as spring Chinook, from June 1 through July 31 are classified as summer Chinook and fish passing after July are classified as fall Chinook. In recent years, fishery managers have used June 16 rather than June 1 to separate spring and summer Chinook salmon. However, in this report, we use the traditional June 1 cutoff.

The fall Chinook run consists of lower river tule and the upriver bright fall Chinook. Tules are considered a lower river fish with most spawning below Bonneville Dam, although a few return to hatcheries between Bonneville and The Dalles dams. They return from the ocean in their spawning colors. By contrast upriver brights are still silver in color when returning from the ocean and spawn upstream of Bonneville Dam.

Sockeye salmon typically migrate between May 15 and August 1 and summer-run steelhead between April 1 and October 31. The steelhead run is further divided into A-run and B-run components based on length (equal or greater than 78 cm for B-run).

Sample Design

Adult fish were sampled one to five days per Statistical Week from April through October. A desired minimum sample size of 610 fish each was set for spring, summer, and fall Chinook, and sockeye salmon is required for age composition. This sample size was derived from simulations we conducted based on the work of Thompson (1987) and assumes that the sample is distributed approximately proportional to the weekly run size. It also assumes that our weekly sample represents a random sample of the run passing over Bonneville Dam that week. These sample sizes achieved precision and accuracy levels of $d=0.05$, $\alpha=0.10$ for age composition estimates. Additional samples were collected to buffer for unreadable scales, to provide more precision in weekly age composition estimates, as well as to meet the goals of other projects which deployed PIT tags and collected genetics samples. A steelhead sample size goal of one percent of the run was set by the U.S. v. Oregon Technical Advisory Committee. The composite age and fin clip proportions estimates were calculated from weekly estimates weighted by the number of each species migrating past Bonneville Dam during the sample week (Fryer 1995). Weekly and annual fish passage counts were obtained from Fish Passage Center (2013). In 2013, genetic material was taken for genetic stock monitoring and identification program for all salmon and steelhead, including tules. Tule sample numbers are not representative of the run and scales are not collected.

In the 2013 sampling season a picket lead drop and lift schedule was maintained in the Washington fish ladder to move salmon and steelhead into the AFF trap (Figure 2). Depending on adult salmon migration density, the four picket leads needed to be periodically raised to allow fish to bypass the AFF trap. For the exact details see the trapping protocols at http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/2013/final/FPP13_AppG.pdf

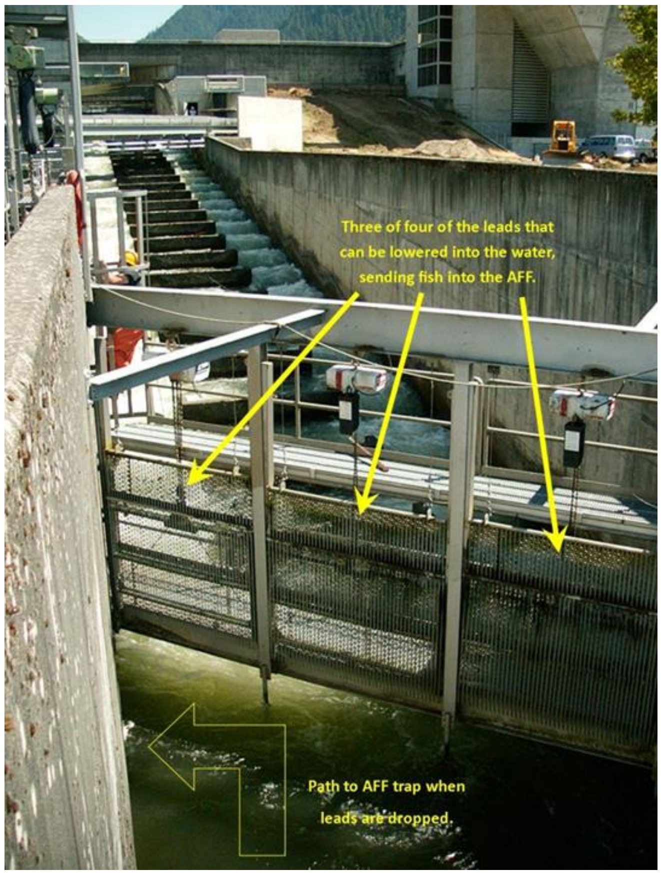

Figure 2. View of Washington Shore Fish Ladder and picket leads that diverted fish into the Bonneville Adult Fish Facility (AFF).

Fish Collection

Fish of each species were trapped at the AFF and anesthetized. Chinook salmon under 36 cm in length were not sampled to reduce our sample of precocious juveniles (known as minijacks), which spend no winters in saltwater. We have excluded minijacks because sampling these fish, which can be very numerous in some years, would reduce our sample of larger fish which are of much greater interest for management and research. Steelhead under 36 cm were also

excluded to avoid sampling rainbow trout. All sizes of sockeye salmon were sampled. Each fish was measured for fork length to the nearest 0.5 cm, checked for identifying fin marks, tags, coloration and condition. Scale samples were collected from all fish for aging and caudal fin tissue was collected for genetic stock composition analysis. These genetic samples will be used in the development of a genetic stock identification program for Columbia River salmon and steelhead. All fish sampled were scanned for PIT tags and any PIT tag codes recorded. In 2013, our goal was to PIT tag all Chinook and sockeye salmon, and steelhead sampled which had not been previously PIT tagged. Recently CRITFC has been collecting some data from a few tules that pass over Bonneville Dam. Scales were not collected from tules; all other data types and genetic samples were collected. All fish were revived in a freshwater tank or pool and returned to a fishway leading to the Washington shore fish ladder.

Fish Coloration and Condition

Fish coloration and condition were recorded for all species at the time of sampling. Coloration was based on qualitative observations with the categories of Bright, Intermediate and Dark. Overall fish condition was also qualitatively assessed and classified on a scale of 1 to 5. Fish classified as a 5 had no major injuries that break the skin, 4 had injuries that broke the skin, 3 had injuries that penetrate the muscle tissue, 2 had injuries that penetrate a body cavity and 1 are fish missing large sections of the body. In addition to the fish condition classification, specific recognizable injuries or afflictions were recorded whenever they were present on the fish and include percentage of descaling, marine mammal injuries, hooking injuries, and net damage. For all other types of injuries, the injury was only recorded if the injury reduced the condition of the fish from a 5 to 4 - 1. This change in protocol, from previous years, was necessary to reduce the amount of time spent on each fish so that more fish could be sampled and tagged.

Age Determination

To minimize the scale sample rejection rate, six scales (three per side) were collected for each Chinook and steelhead sampled (Knudsen 1990) and four scales (two per side) were collected from each sockeye salmon sampled. Scales were mounted and pressed according to methods described by Clutter and Whitesel (1956) and the International North Pacific Fisheries Commission (1963). Individual samples were visually examined and categorized using well-established scale age-estimation methods (Gilbert 1912, Rich and Holmes 1928). Only a

subsample of scale ages could be validated (Beamish and McFarlane 1983) by using the tag code of previously PIT tagged fish. The total age from release to recapture at Bonneville Dam could be compared to that estimated from scale patterns.

The European method for fish age description (Koo 1962) is used in this report. The number of winters a fish spent in freshwater (not including the winter of egg incubation) is described by an Arabic numeral followed by a period. The number following the period indicates the number of winters a fish spent in saltwater. Total age, therefore, is equal to one plus the sum of both numerals. If poor scale quality, particularly in the freshwater prevents age determination in all scales collected from a particular fish, no age is assigned. The exception is steelhead, where if saltwater age can be reliably determined, the age is designated as r.X where X is the saltwater age and "r" stands for regenerated.

For the fall Chinook run, tules that pass Bonneville Dam are removed from the run counts used in the age composition tables. We only report the upriver bright age data; scales are not collected from tules for age analysis.

Age and Length-at-Age Composition

Age composition was estimated by weighting the proportion of each age class sampled by the total counts of each species passing Bonneville dam during each Statistical Week. Length-at-age composition estimates (tables in the Appendix) were not weighted by weekly run size.

Steelhead Hatchery/Wild Determination

Most hatchery reared steelhead in the Columbia River Basin are marked by removing a fin, typically the adipose fin. Crowded hatchery conditions also commonly result in erosion of the dorsal fin which is readily apparent in returning adults. Some hatchery-origin steelhead are released unmarked and to identify these individuals, dorsal fin erosion or scale pattern analysis methods were used. Hatchery steelhead typically experience faster freshwater growth which results in relatively wide spaces between circuli, whereas natural origin fish typically show much slower fresh water growth narrowing the distance between circuli. In addition, hatchery origin fish are reared to smolt in a single year whereas the natural origin fish tend to remain in fresh water for two or more years.

Steelhead A/B Run Determination

Steelhead are divided into A and B run steelhead, where A run steelhead are less than 78 cm in length while B run steelhead are greater than, or equal, to 78 cm in fork length. A-run steelhead occur throughout the Columbia and Snake river basins and rarely exceed the length of 78 cm, whereas B-run steelhead are thought to be produced only in the Clearwater, Middle Fork Salmon, and South Fork Salmon rivers and typically exceed 77.5cm (U.S. v. Oregon 1997). Determination of A-run or B-run was based on length measurement.

Steelhead Kelts

Unlike other species of Pacific salmon (Oncorhynchus spp.), anadromous steelhead naturally exhibit varying degrees of iteroparity (repeat spawning). Successful steelhead iteroparity involves downstream migration of kelts (post-spawned steelhead) to the estuary or ocean environments (Hatch et al. 2003). During scale pattern analysis we found a few steelhead scales to have an iteroparous scale pattern. A kelt scale age is indicated through the use of the letter "S" to indicate spawning. For instance, a steelhead of Age 1.2S1 would have one freshwater annulus, two saltwater annuli, a spawning check, followed by one saltwater annulus. Note that scale resorption often occurs in kelts which can eliminate saltwater annuli marks so a kelt is likely older than would be indicated by summing the annuli and is a separate age class in the age composition table.

Chinook Salmon Run-Size Prediction for 2014

Salmon mature and return to spawn between two and seven years of age. Age composition, life history and total age vary among species. For this analysis a brood year (BY) is defined as the year in which the eggs are fertilized and a brood is defined as all the returning progeny of a given BY. A run-size prediction model is based on the relationship between the survivors within a single brood returning at different ages in successive years.

Fryer and Schwartzberg (1994) determined that adult returns of Columbia basin Chinook are comprised almost entirely of 3, 4 and 5 year old fish, with the proportions of each age class being relatively constant across years. As such, the number of three-year-old fish for a given BY is a relatively good predictor of the number of four-year-old fish from the same BY that would return in the subsequent year. The CRITFC uses this relationship and a regression analysis (Neter et al. 1985, Weisberg 1985) to predict the abundance of four-year-old fish for the next

year, based on the number of three-year-old fish estimated to have returned in this sample year.

RESULTS

Sampling

Sampling began on April 22 and ended October 14, 2013. A total of 1011 spring Chinook, 943 summer Chinook, and 1475 fall Chinook salmon, 799 sockeye salmon, and 1280 steelhead were sampled. During the fall run, 13 additional Chinook salmon were sampled and identified as tules. Genetic samples were taken and almost all fish sampled were tagged with PIT tags for tracking. The PIT tag study results are also reported on an annual basis and are available for download on the CRITFC website.

We attempted to avoid sampling salmonids that spent no winters in saltwater (such Chinook are known as minijacks) by not selecting fish under 36 cm. However, in 2013, we did sample eight Chinook salmon, which spent no winters in saltwater. These fish were treated like other fish at the time of sampling; genetic samples were taken and they were tagged with PIT tags and tracked. For the purposes of this age composition study, these Chinook were considered minijacks and excluded from further analysis.

Age Composition

Based on scale pattern analysis, four-year-olds were the majority age group for spring Chinook salmon, comprising 53.8% of the spring Chinook migration (Figure 3, Table 1). Four-year-olds were the most abundant group for summer Chinook salmon comprising 39.7% of the summer Chinook migration (Figure 3, Table 2), and three-year-olds were the most abundant for fall Chinook salmon, at 50.3% of the fall run (Figure 3, Table 3). A portion of the fall run at Bonneville consists of tules, which we do not include in our analysis. Over 62,000 tules passed Bonneville Dam in 2013. Data from Fish Passage Center starts the tule count on August 15th during the fall Chinook run. Tule numbers were removed from the run numbers in Table 3 for the analysis of fall (upriver bright) Chinook.

The percentage of ocean-type Chinook salmon (age 0.X) increased steadily through the run, from 0% in Statistical Week 17 to a peak of 100.0% in Statistical Weeks 32 and 38 (Figure 4). Sampling hours were restricted during Statistical Weeks 30 to 38 due to high water temperatures.

Four-year-olds were the vast majority of the age groups for sockeye salmon (63.2%), three-year-old and five-year-old were nearly equal in their distribution at 17.4% and 19.4% respectively in 2013 (Table 4).

Four-year-olds comprised 43.0% of the steelhead run. Three-year-olds made up the significant portion at 43.9% while the remaining run consisted of smaller numbers of five-year-olds (12.0%) and six-year-olds made up the rest of the age groups (Table 5). Steelhead with unageable freshwater, but ageable saltwater winters (r.X) comprised 16.4% of the steelhead sampled. If these fish are included with ageable fish and the data are analyzed for salt years only, then the majority of steelhead had one-salt winters (70.6%) in 2013.

Aging validation from ageable scale patterns of 66 salmon or steelhead that had been previously PIT tagged (most likely as juveniles) with ageable scales were correctly aged as follows: all 21 spring Chinook, all 18 summer Chinook, all 8 fall Chinook salmon, all 18 steelhead and the single sockeye salmon. Note that only total age since release could be validated; it normally was not possible to validate saltwater and freshwater separately.

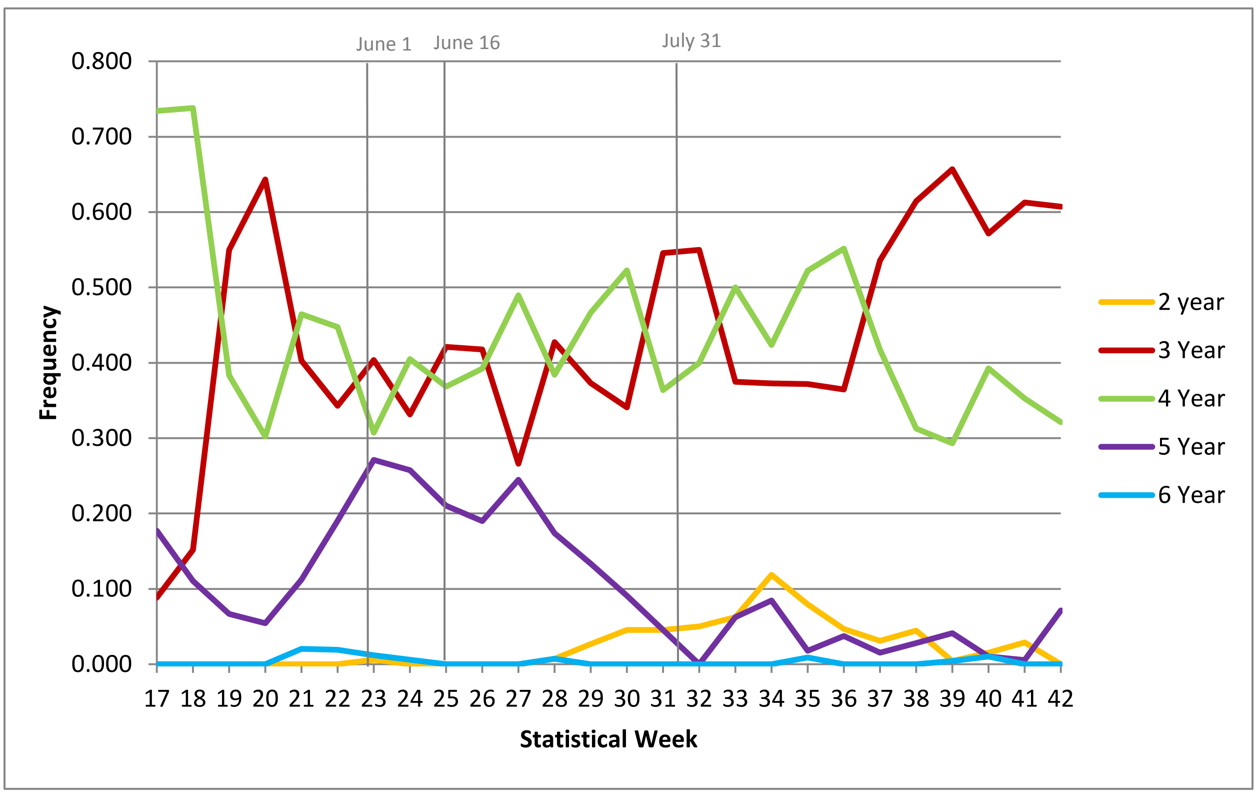

Figure 3. Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2013. Due to high water temperatures, sampling hours were restricted in weeks 30-38. Spring chinook pass Bonneville Dam April 1 to May 31 (TAC dates are April 1 to June 15), summer Chinook pass the dam from June 1 to July 31 (TAC dates are June 16 to July 31), and fall Chinook pass Bonneville Dam August 1 to Oct 31.

Table 1. Weekly and cumulative age composition of Columbia Basin spring Chinook salmon at Bonneville Dam in 2013.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	2011 0.1	2010 0.2	2010 1.1	2009 0.3	2009 1.2	2008 0.4	2008 1.3	2007 1.4	Adipose Clips	Adipose w/Other	Other Clips
					Age Composition by Brood Year and Age Class										
17	4/22 - 4/26	109	79	21035	0.000	0.000	0.089	0.000	0.734	0.000	0.177	0.000	79	1	1
18	4/29-5/03	184	145	30343	0.000	0.007	0.145	0.007	0.731	0.000	0.110	0.000	130	0	0
19	5/6-5/10	146	120	33045	0.000	0.000	0.550	0.000	0.383	0.000	0.067	0.000	99	1	1
20	5/13-5/17	245	202	15541	0.000	0.005	0.639	0.005	0.297	0.005	0.050	0.000	144	3	1
21	5/20-5/24	213	196	10375	0.000	0.005	0.398	0.010	0.454	0.005	0.107	0.020	117	1	0
22	5/28-5/31	114	105	6826	0.000	0.000	0.343	0.019	0.429	0.019	0.171	0.019	52	0	0
Cumulative		**1011**	**847**	**117165**	**0.000**	**0.003**	**0.348**	**0.004**	**0.534**	**0.002**	**0.105**	**0.003**	**621**	**6**	**3**

The weekly run size for Statistical Week 17 includes Chinook salmon passing prior to week 17.

We use May 31 as the end of the spring run, as is generally used in the region (http://www.fpc.org/documents/metadata/FPC_Adult_Metadata.html).

The United States v. Oregon Technical Advisory Committee (http://www.fws.gov/Pacific/fisheries/hatcheryreview/Reports/snakeriver/SR--079.2008-2017.USvOR.Management.Agreement_042908.pdf) uses June 15 as the end of the spring run.

Table 2. Weekly and cumulative age composition of Columbia Basin summer Chinook salmon at Bonneville Dam in 2013.

					Age Composition by Brood Year and Age Class										
Statistical	Sampling	Number	Number	Weekly	2011	2010		2009		2008		2007	Adipose Clips	Adipose w/Other	Other Clips
Week	Date	Sampled	Ageable	run size	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4			
23	6/3-6/7	190	166	17742	0.006	0.018	0.386	0.090	0.217	0.006	0.265	0.012	102	1	0
24	6/10-6/14	185	163	19658	0.000	0.049	0.282	0.178	0.227	0.006	0.252	0.006	92	2	0
25	6/19-6/21	67	57	22421	0.000	0.123	0.298	0.140	0.228	0.018	0.193	0.000	30	0	0
26	6/24-6/27	89	79	16272	0.000	0.101	0.316	0.089	0.304	0.000	0.190	0.000	45	0	0
27	7/1-7/3	106	94	15998	0.000	0.074	0.191	0.149	0.340	0.000	0.245	0.000	60	1	0
28	7/8-7/12	150	138	11073	0.007	0.232	0.196	0.225	0.159	0.000	0.174	0.007	56	0	0
29	7/15-7/19	89	75	6675	0.027	0.267	0.107	0.280	0.187	0.027	0.107	0.000	41	0	0
30	7/22-7/26	49	44	5140	0.045	0.295	0.045	0.250	0.273	0.000	0.091	0.000	21	0	0
31	7/30-7-31	18	17	3140	0.000	0.412	0.235	0.235	0.059	0.000	0.059	0.000	2	0	1
Cumulative		**943**	**833**	**118119**	**0.005**	**0.119**	**0.264**	**0.156**	**0.241**	**0.007**	**0.205**	**0.004**	**449**	**4**	**1**

Due to high water temperatures, sampling hours were restricted in weeks 30-38.

June 1 is designated as the start of the summer run and is generally used in the region ((http://www.fpc.org/documents/metadata/FPC_Adult_Metadata.html).

The United States v. Oregon Technical Advisory Committee (http://www.fws.gov/Pacific/fisheries/hatcheryreview/Reports/snakeriver/SR--079.2008-2017.USvOR.Management.Agreement_042908.pdf) uses June 16 as the start of the summer run.

Table 3. Weekly and cumulative age composition of Columbia Basin fall Chinook salmon at Bonneville Dam in 2013.

Statistical	Sampling	Number	Number	URB	Age Composition by Brood Year and Age Class											
					2011	2010		2009		2008		2007		Adipose Clips	Adipose w/Other	Other Clips
Week	Date	Sampled	Ageable	run size	0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4			
31	7/30, 7/31, 8/2	5	5	1785	0.200	0.200	0.000	0.400	0.200	0.000	0.000	0.000	0.000	0	0	0
32	8/6, 8/9	22	20	10755	0.050	0.550	0.000	0.400	0.000	0.000	0.000	0.000	0.000	5	0	0
33	8/13 - 8/16	84	80	15308	0.063	0.363	0.013	0.425	0.075	0.038	0.025	0.000	0.000	27	0	0
34	8/22, 8/23	61	59	44747	0.119	0.322	0.051	0.390	0.034	0.085	0.000	0.000	0.000	19	0	0
35	8/27 - 8/30	121	113	140446	0.080	0.310	0.062	0.513	0.009	0.009	0.009	0.000	0.009	34	0	0
36	9/5, 9/6	114	107	161846	0.047	0.346	0.019	0.551	0.000	0.028	0.009	0.000	0.000	29	0	0
37	9/10 - 9/12	212	194	284840	0.031	0.536	0.000	0.412	0.005	0.015	0.000	0.000	0.000	73	0	0
38	9/17 - 9/20	188	179	160174	0.045	0.615	0.000	0.313	0.000	0.028	0.000	0.000	0.000	50	0	0
39	9/23 - 9/27	255	242	84117	0.004	0.645	0.012	0.289	0.004	0.037	0.004	0.004	0.000	58	0	0
40	9/30 - 10/4	206	196	39494	0.015	0.566	0.005	0.388	0.005	0.010	0.000	0.010	0.000	58	0	0
41	10/7 - 10/11	179	173	31178	0.029	0.613	0.000	0.335	0.017	0.006	0.000	0.000	0.000	43	0	0
42	10/14	28	28	26880	0.000	0.571	0.036	0.321	0.000	0.071	0.000	0.000	0.000	9	0	0
Cumulative		**1475**	**1396**	**1001570**	**0.044**	**0.487**	**0.016**	**0.416**	**0.007**	**0.025**	**0.003**	**0.001**	**0.001**	**405**	**0**	**0**

August 1 is the start of the fall run at Bonneville Dam.

Due to high water temperatures, sampling hours were restricted in weeks 30-38.

The weekly run size for week 42 includes all Chinook salmon passing Bonneville Dam after the last date of sampling in week 42.

Tule numbers passing Bonneville Dam per week are removed from the Bright (URB) run size.

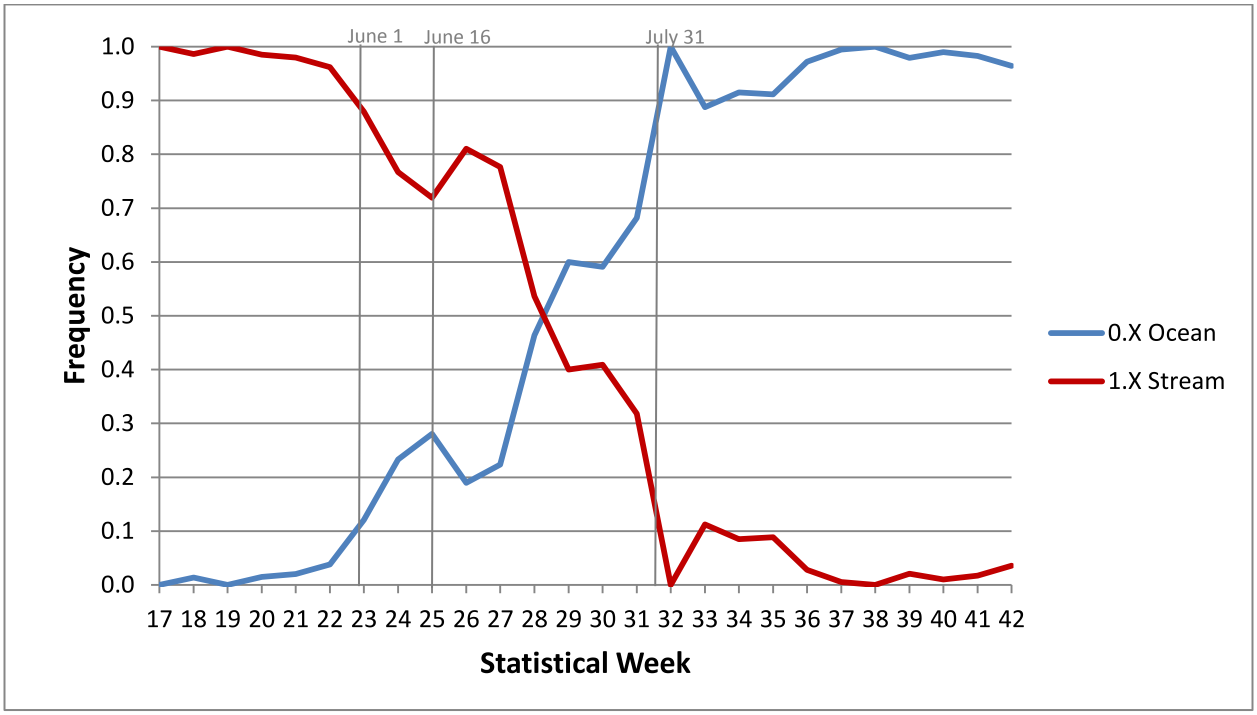

Figure 4. Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2013. Due to high water temperatures, sampling hours were restricted in weeks 30-38. Spring chinook pass Bonneville Dam April 1 to May 31 (TAC dates are April 1 to June 15), summer Chinook pass the dam from June 1 to July 31 (TAC dates are June 16 to July 31), and fall Chinook pass Bonneville Dam August 1 to Oct 31.

Table 4. Weekly and cumulative age composition of Columbia Basin sockeye salmon at Bonneville Dam in 2013.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	2010	2009		2008		Adipose Clips	Adipose w/Other	Other Clips
					1.1	1.2	2.1	1.3	2.2			
23	6/3-6-7	16	16	2246	0.000	0.625	0.000	0.375	0.000	0	0	0
24	6/10-6-14	148	140	16807	0.021	0.679	0.000	0.250	0.050	1	0	2
25	6/19-6/21	140	139	40879	0.007	0.770	0.000	0.180	0.043	0	0	2
26	6/24-6/27	232	229	49628	0.066	0.721	0.000	0.127	0.087	7	0	0
27	7/1-7/3	85	81	37818	0.222	0.642	0.012	0.086	0.037	1	0	0
28	7/8-7/12	117	113	25433	0.416	0.407	0.009	0.080	0.088	1	0	0
29	7/15-7/19	47	47	9214	0.702	0.128	0.021	0.085	0.064	0	0	0
30	7/22-7/26	10	10	2284	0.900	0.100	0.000	0.000	0.000	0	0	0
31-32	7/30-8/2, 8/6-8/9	4	4	1111	0.750	0.250	0.000	0.000	0.000	0	0	0
Cumulative		**799**	**779**	**185420**	**0.174**	**0.627**	**0.005**	**0.134**	**0.060**	**10**	**0**	**4**

Age Composition by Brood Year and Age Class

Statistical weeks 31-32 have been combined due to low sampling numbers at the end of the run.

The weekly run size for week 23 includes sockeye salmon passing prior to this week. Similarly the weekly run size for week 30-31 includes fish passing after this week.

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Table 5. Weekly and cumulative age composition of Columbia Basin steelhead at Bonneville Dam in 2013.

Statistical	Sampling	Number	Number	Weekly	Age Composition by Brood Year and Age Class: 2010	2009		2008			2007			Ageable Salt_Winters				A-Run	Fin Cllips			Wild
Week	Date	Sampled	Ageable	run size	1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	Repeat	1 ASW	2 ASW	3 ASW		Ad Clips	Ad + Other	Other	
17	4/22-4/26	8	5	137	0.200	0.800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.286	0.714	0.000	0.875	4	3	0	0.000
18	4/29-5/3	5	5	141	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	1.000	4	1	0	0.000
19	5/6-5/10	8	6	121	0.167	0.667	0.000	0.167	0.000	0.000	0.000	0.000	0.000	0.000	0.143	0.714	0.143	0.875	8	0	0	0.000
20	5/13-5/17	8	5	153	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.750	0.125	0.875	8	0	0	0.000
21	5/20-5/24	16	9	193	0.000	0.444	0.000	0.333	0.111	0.000	0.111	0.000	0.000	0.000	0.000	0.571	0.429	0.688	13	0	0	0.188
22	5/28-5/31	11	8	284	0.125	0.750	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.091	0.818	0.091	1.000	9	0	0	0.182
23	6/3-6/7	7	6	436	0.167	0.833	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.286	0.714	0.000	1.000	7	0	0	0.000
24	6/10-6/14	5	3	499	0.000	0.667	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.600	0.400	0.800	3	0	0	0.400
25	6/19-6/21	7	6	1122	0.333	0.500	0.167	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.429	0.571	0.000	1.000	2	1	1	0.286
26	6/24-6/27	8	5	1667	0.600	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.750	0.250	0.000	1.000	6	0	0	0.250
27	7/1-7/3	7	4	2573	0.250	0.000	0.500	0.000	0.250	0.000	0.000	0.000	0.000	0.000	0.714	0.286	0.000	1.000	3	0	0	0.571
28	7/8-7/12	49	34	5709	0.324	0.176	0.294	0.000	0.147	0.029	0.000	0.029	0.000	0.000	0.633	0.367	0.000	1.000	16	2	1	0.490
29	7/15-7/19	176	129	13202	0.326	0.124	0.333	0.000	0.147	0.062	0.000	0.000	0.008	0.000	0.741	0.259	0.000	1.000	58	9	0	0.523
30	7/22-7/26	177	129	21274	0.264	0.085	0.473	0.000	0.132	0.047	0.000	0.000	0.000	0.017	0.782	0.218	0.000	0.994	48	7	0	0.605
31	7/30, 7/31, 8/2	104	79	25821	0.405	0.139	0.291	0.000	0.101	0.038	0.000	0.025	0.000	0.019	0.772	0.228	0.000	0.990	46	7	2	0.433
32	8/6, 8/9	89	63	50602	0.540	0.063	0.238	0.000	0.095	0.032	0.000	0.016	0.016	0.034	0.835	0.165	0.000	1.000	41	9	1	0.404
33	8/13-8/16	159	117	22741	0.444	0.120	0.299	0.000	0.111	0.026	0.000	0.000	0.000	0.019	0.763	0.237	0.000	1.000	70	11	0	0.453
34	8/22, 8/23	58	46	18370	0.565	0.152	0.239	0.000	0.022	0.022	0.000	0.000	0.000	0.000	0.828	0.172	0.000	1.000	39	2	1	0.276
35	8/27-8/30	107	81	15926	0.494	0.259	0.160	0.000	0.074	0.012	0.000	0.000	0.000	0.009	0.660	0.340	0.000	0.953	63	11	0	0.262
36	9/5, 9/6	28	21	10593	0.619	0.190	0.095	0.000	0.095	0.000	0.000	0.000	0.000	0.000	0.714	0.286	0.000	1.000	17	3	0	0.214
37	9/10-9/12	14	13	14594	0.385	0.462	0.077	0.000	0.077	0.000	0.000	0.000	0.000	0.000	0.429	0.571	0.000	0.929	10	0	0	0.143
38	9/17-9/20	56	41	7767	0.390	0.512	0.049	0.000	0.049	0.000	0.000	0.000	0.000	0.000	0.436	0.545	0.018	0.696	39	1	1	0.161
39	9/23-9/27	61	42	7238	0.524	0.333	0.048	0.000	0.095	0.000	0.000	0.000	0.000	0.000	0.559	0.441	0.000	0.836	37	2	1	0.148
40	9/30-10/4	53	40	4843	0.275	0.600	0.050	0.000	0.075	0.000	0.000	0.000	0.000	0.000	0.365	0.635	0.000	0.679	33	2	1	0.151
41	10/7-10/11	49	43	2698	0.326	0.628	0.023	0.000	0.000	0.000	0.023	0.000	0.000	0.021	0.340	0.638	0.021	0.571	38	1	0	0.082
42	10/14	10	8	2912	0.125	0.750	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.200	0.800	0.000	0.400	5	1	0	0.100
Cumulative		**1280**	**948**	**231616**	**0.439**	**0.195**	**0.235**	**0.001**	**0.094**	**0.025**	**0.000**	**0.007**	**0.004**	**0.014**	**0.706**	**0.291**	**0.002**	**0.955**	**627**	**73**	**9**	**0.363**

Due to high water temperatures, sampling hours were restricted in weeks 30-38.

Number ageable (fresh and salt years) is used to calculate the X.X age classes.

All fish (except completely unageable – total of 16) were used in the calculation of Repeat spawners

All fish (except completely unageable and repeat spawners – total of 30) were used in the calculations of Ageable Salt-Winters.

B-run fish are 1 – A-run weekly proportion.

Length-at-Age Composition

Length-at-age composition estimates for all Chinook salmon are presented in Figure 5 and the Appendix. Length-at-age tables for sockeye salmon and steelhead are also located in the Appendix.

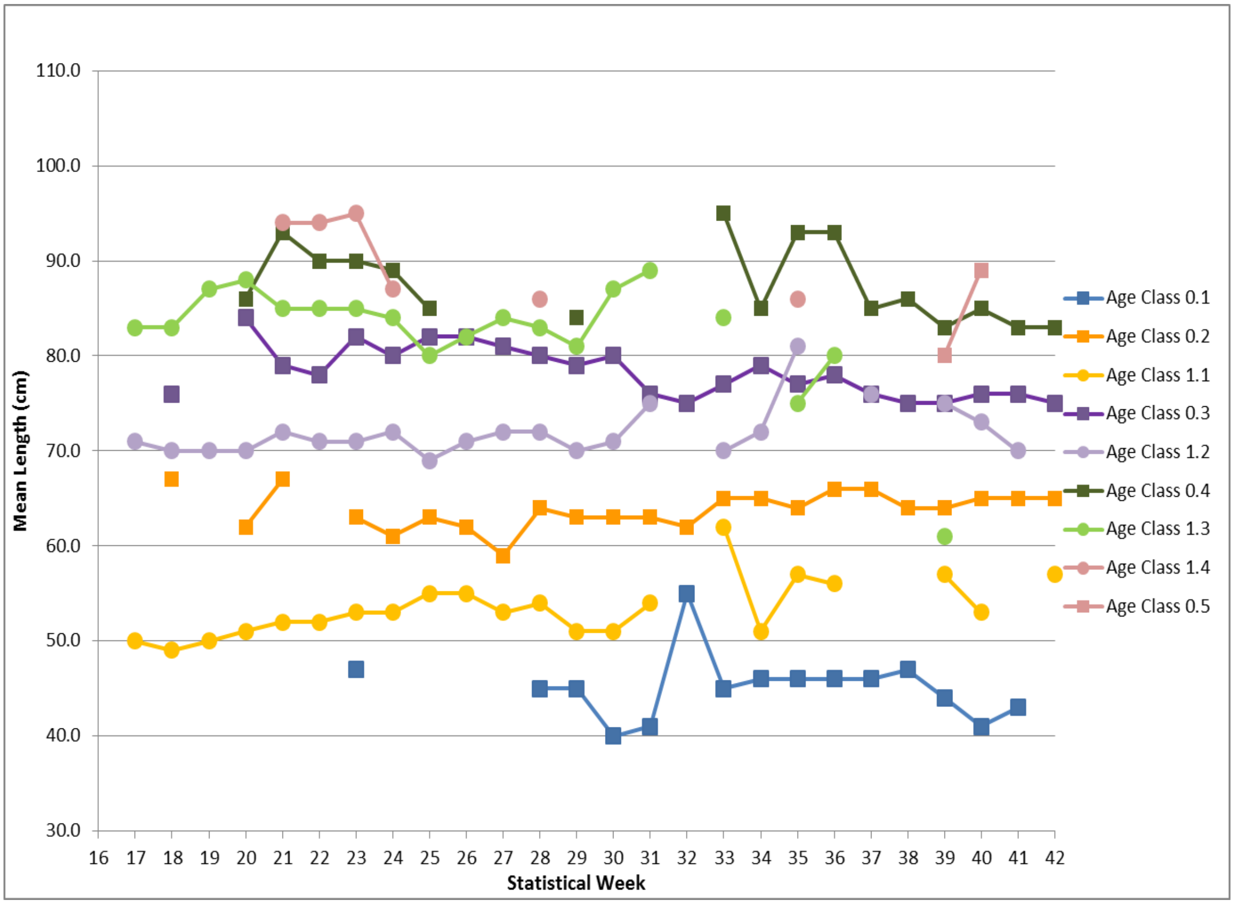

Figure 5. Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2013. Due to high water temperatures, sampling hours were restricted in weeks 30-38.

Fish Coloration and Condition

Bright coloration was observed in the majority of each species: 55.3% of spring Chinook salmon, 75.4% of summer Chinook, 65.8% of fall Chinook, 99.6% of sockeye salmon and 92.2% of steelhead. The highest condition rating of 5 was given to 88.5% of spring Chinook, 85.7% of summer Chinook, 77.8% of fall Chinook, 93.5% of sockeye and 79.5% of steelhead. Additional fish condition data can be found in the Appendix (Note – due to protocol change, the number of some types of injuries reported were greatly reduced).

Chinook Salmon Run-Size Prediction for 2014

Using a linear relationship between the 2013 three- and four-year-old adult returns (Figure 6), the estimated number of four-year-old spring Chinook salmon returning to Bonneville Dam in 2014 is 278,500 (±106,800, 90% prediction interval [PI]). Using the relationship between four- and five-year-olds to construct the model (Figure 7), we predict that the 2014 five-year-old adult abundance at Bonneville Dam will be 17,900 (±37,000, 90% PI).

For the 2014 summer Chinook salmon run at Bonneville Dam, the relationship between three- and four-year-olds (Figure 8) results in a prediction of 60,100 (±32,500, 90% PI) four-year-olds. The relationship between four- and five-year-olds (Figure 9), the model predicts a return of 30,400 (±19,900, 90% PI) five-year-olds.

Based on the relationship between three- and four-year-olds (Figure 10), the model results in a prediction of 637,700 (±285,800, 90% PI) four-year-old Upriver Bright fall Chinook salmon returns for 2014. Using the relationship between four- and five-year-olds (Figure 11), the model results in a prediction of 191,300 (±91,600, 90% PI) returning five-year-olds.

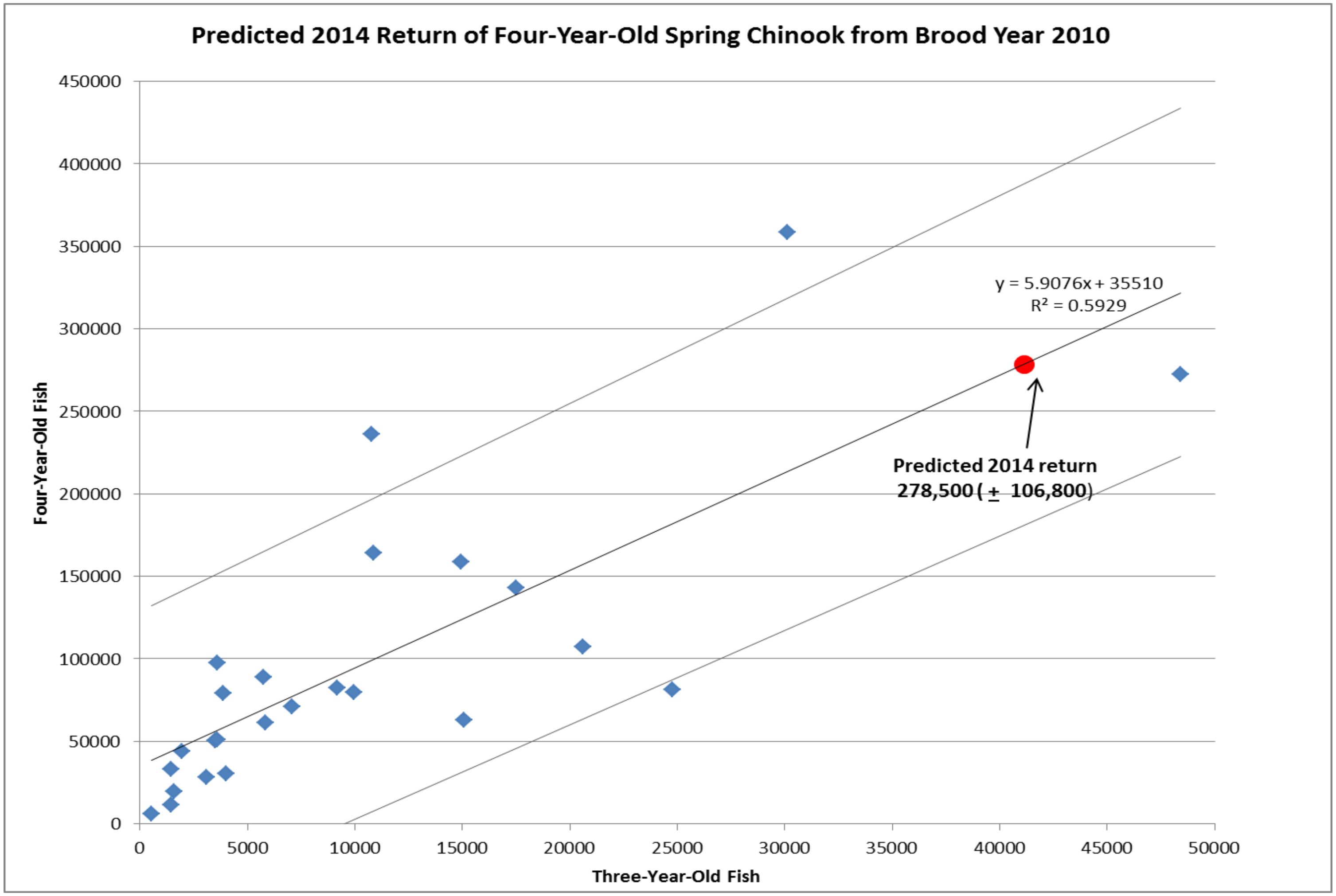

Figure 6. Predicted 2014 four-year-old Columbia Basin spring Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1984 through 2010. Prediction intervals (90%) are also graphed.

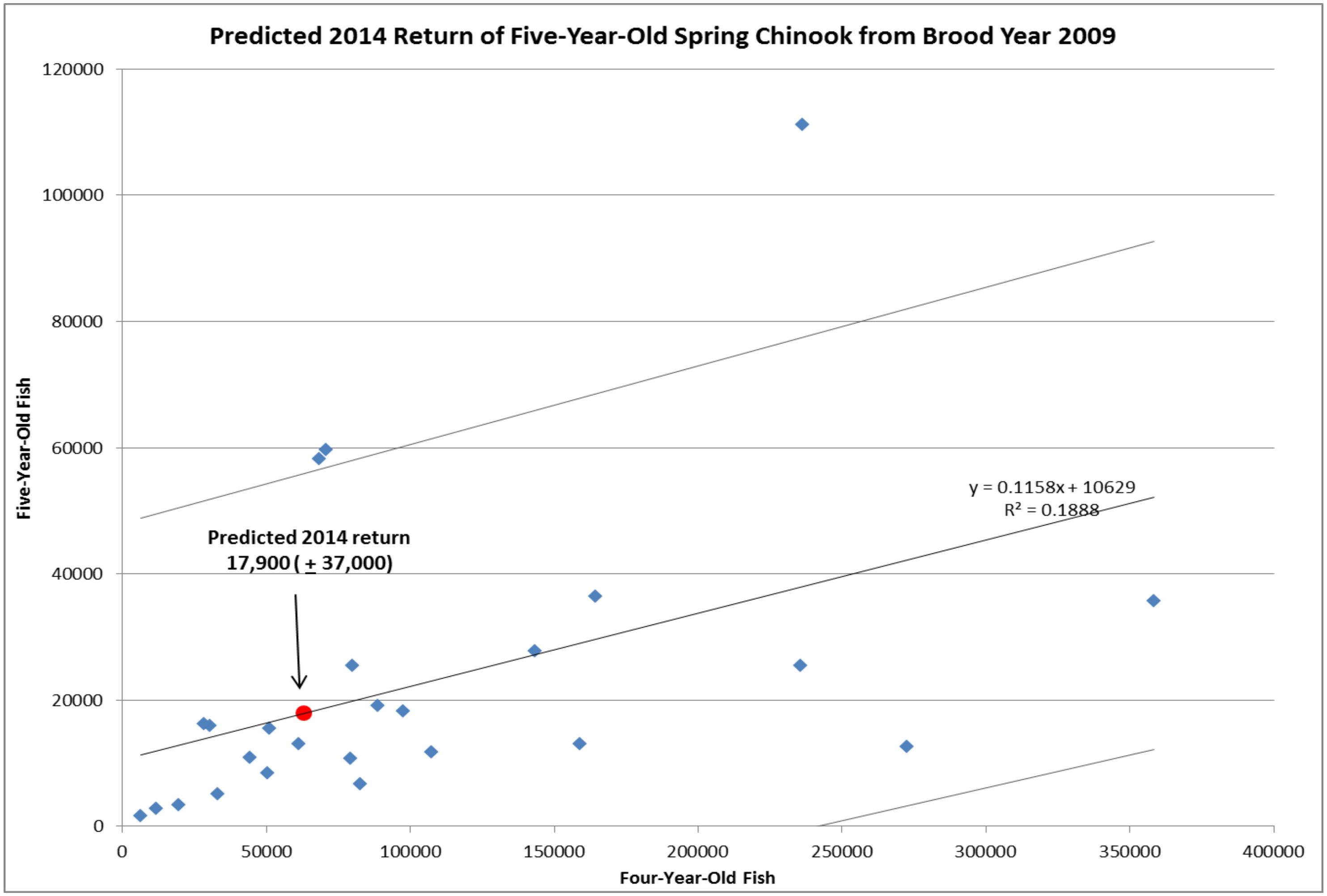

Figure 7. Predicted 2014 five-year-old Columbia Basin spring Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1983 through 2009. Prediction intervals (90%) are also graphed.

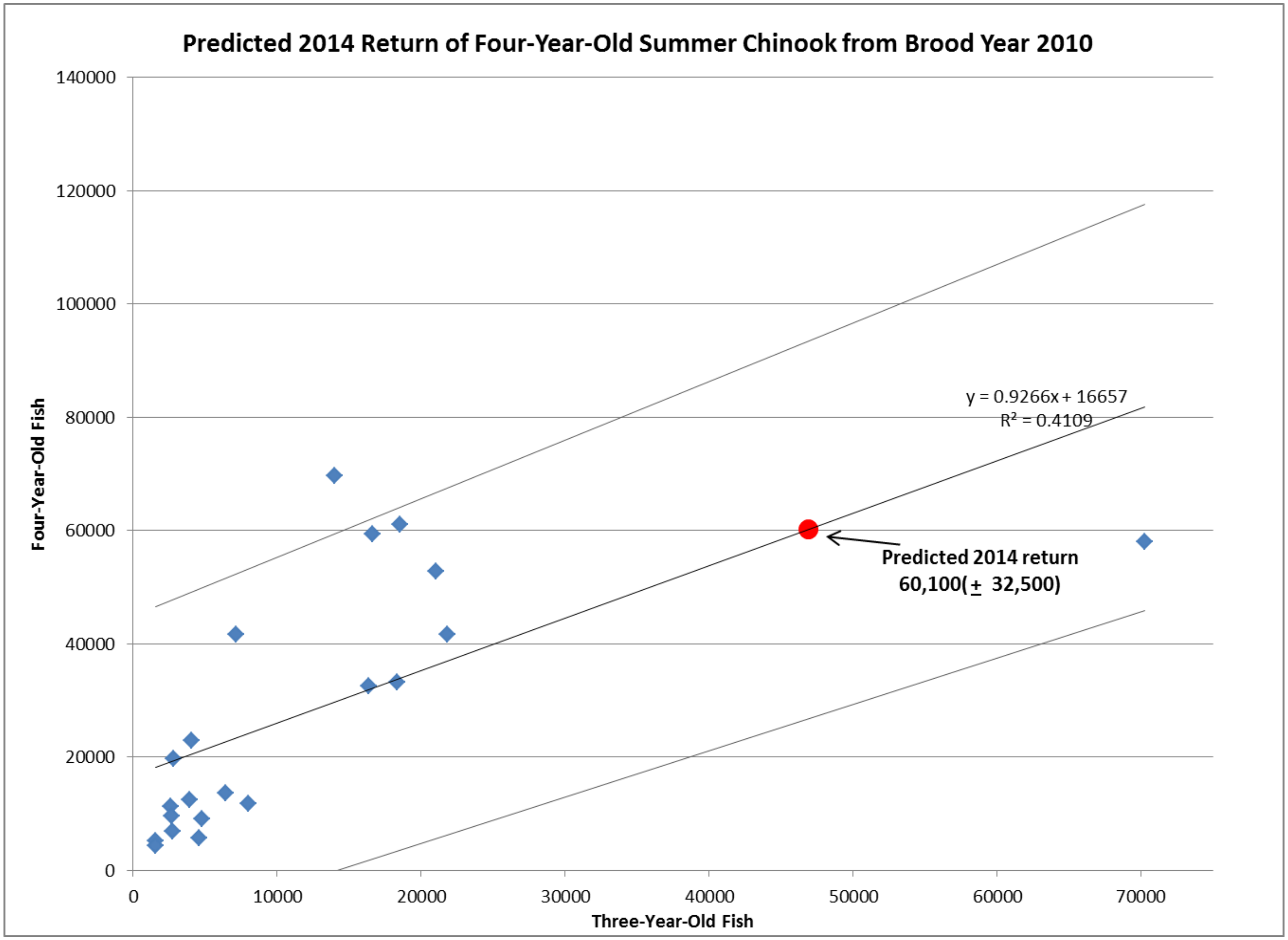

Figure 8. Predicted 2014 four-year-old Columbia Basin summer Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1987 through 2010. Prediction intervals (90%) are also graphed.

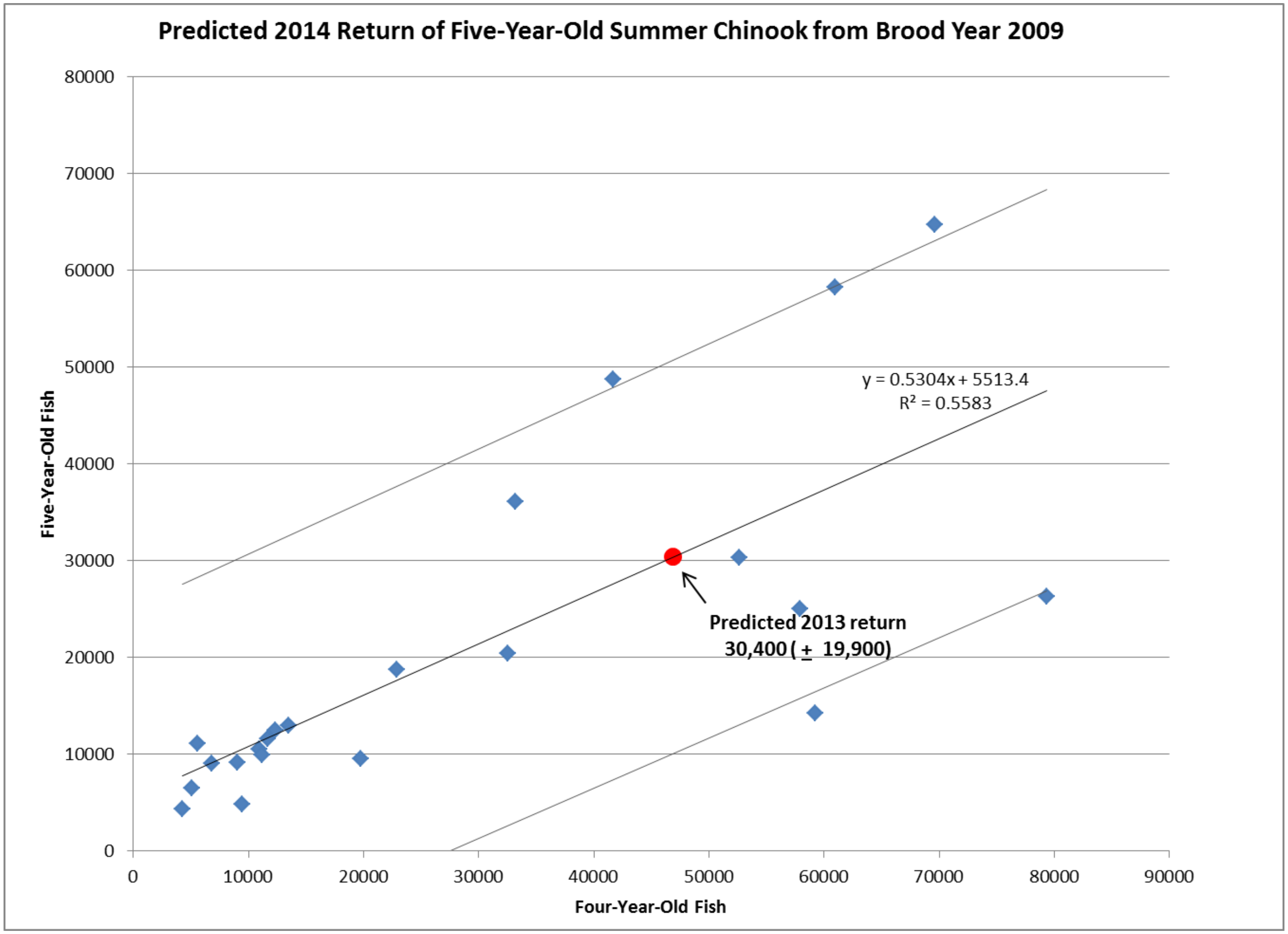

Figure 9. Predicted 2014 five-year-old Columbia Basin summer Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1986 through 2009. Prediction intervals (90%) are also graphed.

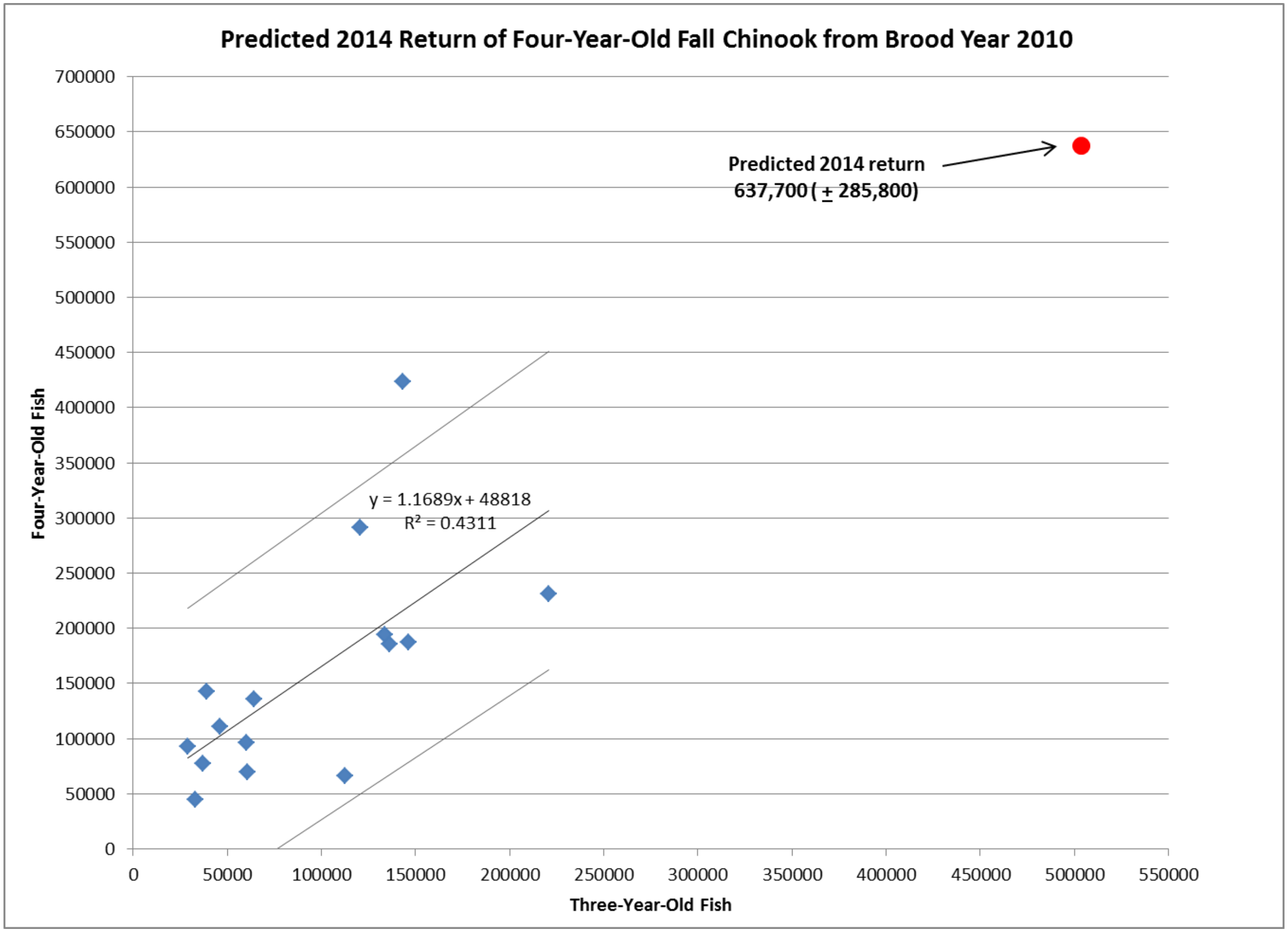

Figure 10. Predicted 2014 four-year-old Columbia Basin fall Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1994 through 2010. Prediction intervals (90%) are also graphed.

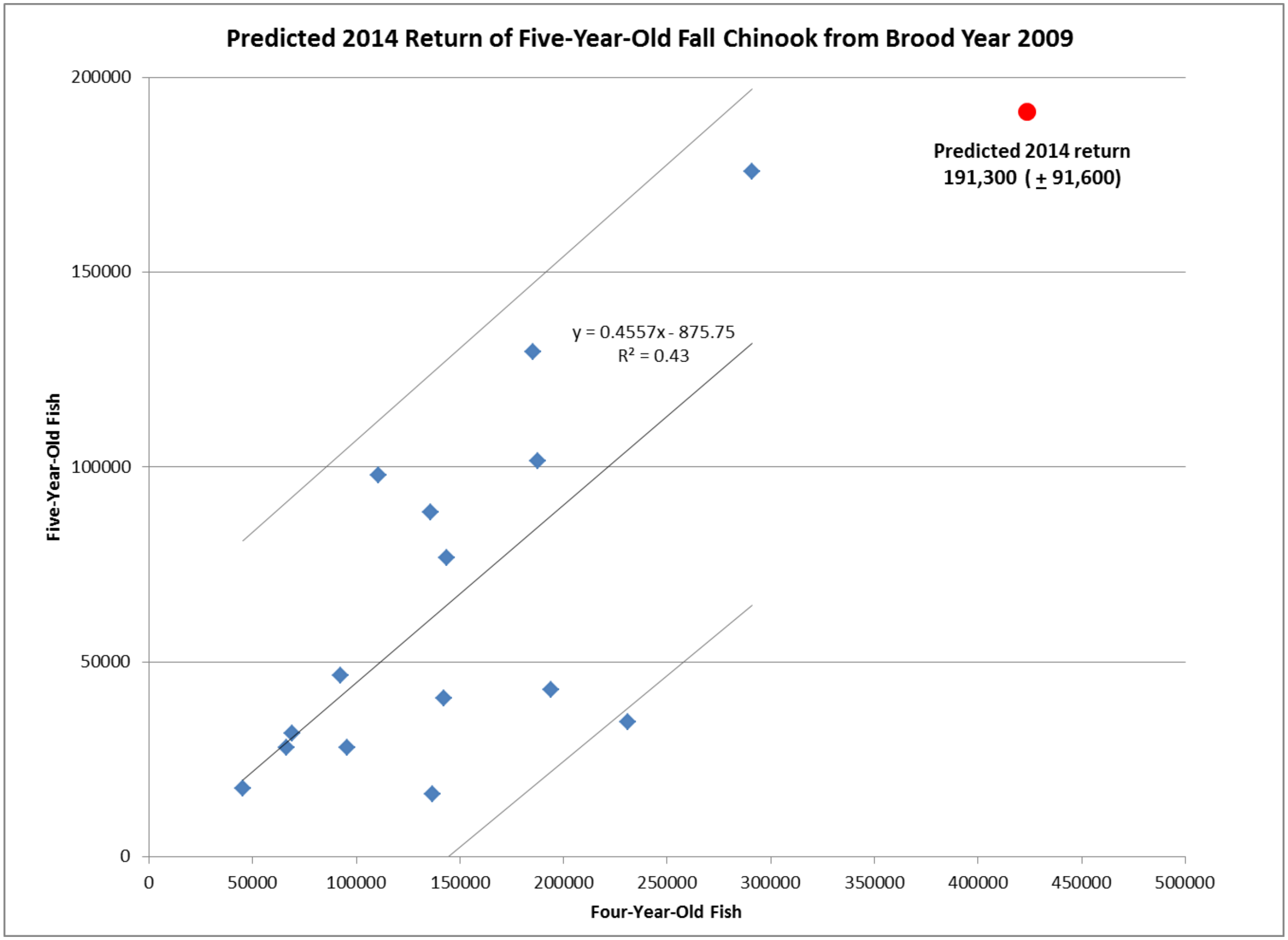

Figure 11. Predicted 2014 five-year-old Columbia Basin bright fall Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and five-year-old fish abundance during brood years 1993 through 2009. Prediction intervals (90%) are also graphed.

Steelhead Hatchery/Wild Determination

The vast majority of hatchery raised steelhead are released with a clipped fin, typically an adipose fin. This clip is used primarily in harvest management purposes where some fisheries allow adipose clipped fish to be kept, while non-adipose clipped fish (assumed wild) are released. Separate visual counts are made at Columbia Basin mainstem dams for non-clipped steelhead, allowing managers to estimate the percentage wild fish in the run. However, poorly clipped adipose fins can grow back and there are a small number of hatchery programs that release steelhead unclipped. In the past, steelhead were raised in relatively crowded conditions at hatcheries, which meant that released fish commonly had so-called stubby dorsal fins (and sometimes other fins as well) from other juveniles nipping those fins (Hagerman Hatchery Evaluation Team 2009). This meant that the vast majority of adipose clipped steelhead also had stubby dorsal fins. The stubby dorsal fin was used to determine fish origin in those cases where adipose fins grew back, or where hatcheries released unclipped steelhead. However, steelhead are increasingly raised at lower densities, which should make stubby dorsals more rare in the population. Therefore, we also used scale pattern analysis to classify some unclipped steelhead as hatchery fish. Wild-origin fish typically have freshwater scale patterns showing tight growth with two or more distinct check marks, which are winter annuli. Hatchery-origin fish show much greater freshwater growth and have much less distinct annuli. Our age composition results in Table 5 are based on interpretation of scale patterns. Based on the lack of an adipose fin clip alone, we would have estimated that 45.3% of the run was of wild origin; including scale patterns reduced this to 36.3%.

Steelhead A/B Run Determination

Assuming that A-run (less than 78 cm) and B-run (equal to or greater than 78 cm) steelhead can be differentiated by length alone, the majority of the steelhead run (95.5%) passing Bonneville Dam were A-run, and the remaining 4.5% were B-run. Although A-run steelhead dominated the run, the percentage of the B-run generally increases as the run progresses (Table 5 and Figure 12).

Steelhead Kelts

In 2013, we found 14 steelhead with spawning check marks in their scale patterns. The freshwater- and saltwater-winter annuli numbers varied greatly and two fish had unageable freshwater annuli. All 14 steelhead were PIT tagged and tracked. Three of the fish were adipose (and/or other) clipped and had freshwater scale patterns of hatchery fish.

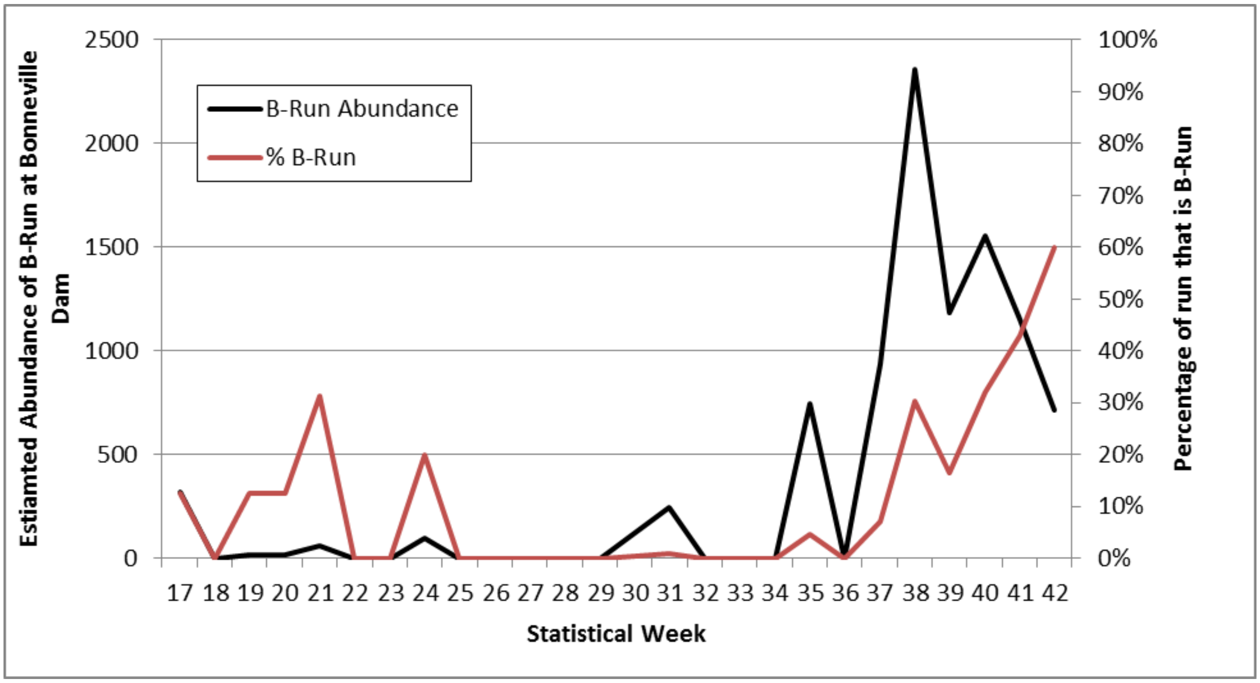

Figure 12. Percentage of B Run steelhead sampled and estimated run size based on B-run proportion of the Bonneville Dam count by Statistical Week in 2013. Due to high water temperatures, sampling hours were restricted in weeks 30-38.

DISCUSSION

High river water temperature has constrained our sampling efforts during most summer sampling seasons. Restrictions for days of sampling, and hours of the day that sampling can occur, are triggered when temperatures reach 70^{o}F (21.1^{o}C). During the 2013 sampling season, sampling was restricted during weeks 30-38 (Figure 7) as temperatures reached a high of 73.04^{o}F for 23 days between Aug 20 and Sept 17. Chinook and steelhead continued to pass Bonneville Dam in relatively large numbers even though temperatures exceeded 70^{o}F. Any link between temperature and passage numbers is much less apparent in 2013 than in previous years.

In 2013, tissue samples (for DNA analysis) were collected from all Chinook and sockeye salmon, and steelhead that were sampled at the Adult Fish Facility at Bonneville Dam. This was the eleventh year for Chinook salmon, the seventh year for sockeye salmon, and the tenth year for steelhead that we have collected genetic samples. Significant progress has been made through the coast wide genetic database to assemble baseline genetic stock identification information for all Columbia River salmon and steelhead populations. The development of genetic reference baselines has been completed and now accurate genetic stock analyses are being performed using 192 genetic markers for both steelhead and Chinook salmon. In addition 96 genetic markers for sockeye salmon have been developed and samples have been analyzed (Hess et al. Annual Reports). Now that this baseline stock information is readily available, mixed stock sampling at Bonneville Dam will be a valuable tool for fisheries and ESA management within the Columbia River Basin.

It is expected that this stock assessment study will continue to develop an accurate age composition and length-at-age database for Columbia Basin upriver salmon populations, and work towards improving the forecasting of terminal runs, which is important for the calibration of the PSC Chinook Technical Committee's Chinook model. These data will also aid fisheries managers in formulating spawner-return relationships and analyzing productivity. Continued data collection on age composition and length-at-age will allow managers to more accurately monitor the effects of ocean harvest restrictions agreed upon by the Pacific Salmon Treaty. The addition of steelhead to our normal sampling regime provides valuable information for NOAA-Fisheries and TAC for use in steelhead assessments, fisheries forecasting and harvest management. This study will work to improve accurate age determination, hatchery fraction, and stock identification and assessment.

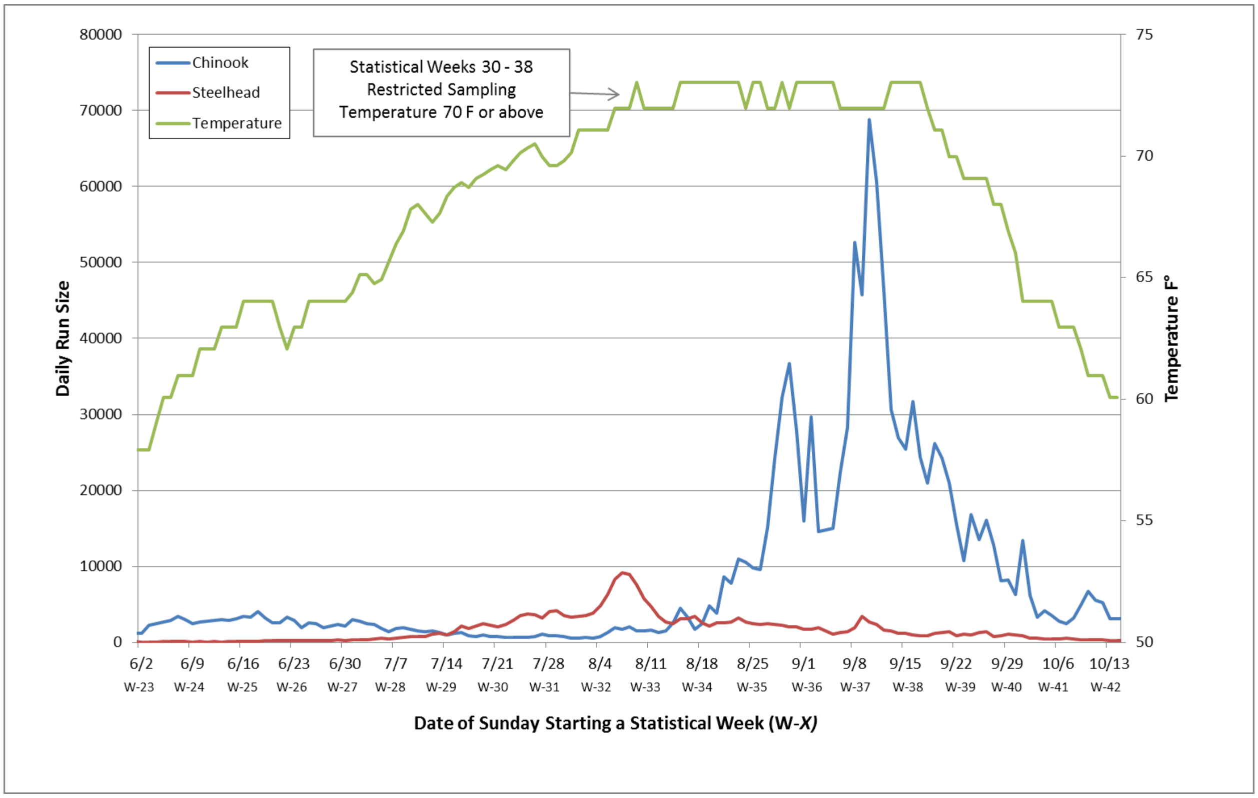

Figure 13. Chinook and steelhead daily run size and daily river temperature at Bonneville Dam for June 1 through October 11, 2013 (statistical weeks 23 through 42).

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APPENDIX

List of Tables

Table A1. Composition (%) of observed injuries of Columbia Basin Chinook and sockeye salmon and steelhead sampled at Bonneville Dam in 2013.

Injury Category	Spring	Summer	Fall	Sockeye	Steelhead
Marine Mammal Bites & Scrapes	8.01	4.77	3.59	1.75	7.66
Descaling					
3-19%	14.94	24.18	22.98	32.67	15.16
>20%	4.85	6.36	9.49	8.51	4.92
Net Marks	1.58	1.91	4.14	0.63	6.72
Hook					
Hook Damage	0.69	1.59	1.36	0.13	1.72
Hook Present	0.10	0.11	0.27	0.00	0.31
Headburn	0.10	0.00	0.00	0.00	0.00
Other Injuries					
Bruise	0.00	0.32	0.81	0.00	0.55
Head Injury	0.20	0.95	0.88	0.00	0.63
Fin Injury	3.26	4.67	4.81	1.75	5.63
Fungus	0.30	0.00	0.41	0.38	0.16
Gash	4.15	4.45	4.95	3.50	5.63
Parasite/Dissease	0.10	0.21	1.29	8.76	9.30

The proportion of marine mammal marks in 2013 was not consistent with other reports due to changes in how other (non-marine mammal) injuries were reported. In past reports, any marine mammal mark was reported regardless of how the mark changed condition. In 2013, CRITFC samplers were inconsistent in the execution of this protocol.
Descaling percent is based on total body and was summarized into only two categories.
Note – due to protocol change, the number of Other injuries reported were greatly reduced (See Sample Design Section)

Table A2. Length-at-age estimates for Columbia Basin spring Chinook salmon sampled at Bonneville Dam in 2013.

Brood Year and	2010		2009		2008		2007
Age Class	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 17							
Mean Fork Length (cm)		49.57		71.36		83.00	
Maximum		60.0		85.5		92.0	
Minimum		43.0		64.5		77.0	
Standard Deviation		5.75		4.12		4.49	
Sample Size		7		58		14	
Statistical Week 18							
Mean Fork Length (cm)	67.00	49.26	75.50	70.07		82.50	
Maximum	67.0	56.5	75.5	79.5		95.0	
Minimum	67.0	43.5	75.5	59.0		71.0	
Standard Deviation	--	3.31	--	3.79		5.29	
Sample Size	1	21	1	106		16	
Statistical Week 19							
Mean Fork Length (cm)		50.23		70.30		86.88	
Maximum		58.0		81.0		98.0	
Minimum		42.5		62.0		80.0	
Standard Deviation		3.86		4.43		5.90	
Sample Size		66		46		8	
Statistical Week 20							
Mean Fork Length (cm)	62.00	51.22	84.00	69.65	86.00	87.60	
Maximum	62.0	58.5	84.0	82.0	86.0	92.0	
Minimum	62.0	41.0	84.0	55.0	86.0	80.0	
Standard Deviation	--	3.72	--	5.76	--	4.00	
Sample Size	1	129	1	60	1	10	
Statistical Week 21							
Mean Fork Length (cm)	67.00	51.73	78.50	71.82	92.50	85.33	93.75
Maximum	67.0	66.0	79.0	85.0	92.5	91.0	97.5
Minimum	67.0	44.0	78.0	53.0	92.5	76.5	87.0
Standard Deviation	--	3.56	0.71	4.72	--	3.94	4.84
Sample Size	1	78	2	89	1	21	4
Statistical Week 22							
Mean Fork Length (cm)		52.26	77.75	71.29	89.75	84.89	93.75
Maximum		60.5	80.0	80.5	94.0	96.5	102.0
Minimum		43.0	75.5	61.0	85.5	71.0	85.5
Standard Deviation		4.06	3.18	4.61	6.01	7.17	11.67
Sample Size		36	2	45	2	18	2
2013 Composoite							
Mean Fork Length (cm)	**65.33**	**51.10**	**78.67**	**70.74**	**89.50**	**84.75**	**93.75**
Maximum	**67.0**	**66.0**	**84.0**	**85.5**	**94.0**	**98.0**	**102.0**
Minimum	**62.0**	**41.0**	**75.5**	**53.0**	**85.5**	**71.0**	**85.5**
Standard Deviation	**2.89**	**3.83**	**3.19**	**4.59**	**4.38**	**5.39**	**6.42**
Sample Size	**3**	**337**	**6**	**404**	**4**	**87**	**6**

Table A3. Length-at-age estimates for Columbia Basin summer Chinook salmon sampled at Bonneville Dam in 2013.

Brood Year and	2011	2010		2009		2008		2007
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 23								
Mean Fork Length (cm)	46.50	62.83	52.82	81.63	70.89	90.00	85.24	95.25
Maximum	46.5	68.5	60.0	92.5	83.5	90.0	99.0	97.5
Minimum	46.5	58.0	39.5	66.0	62.0	90.0	74.5	93.0
Standard Deviation	--	5.30	3.65	7.57	4.99	--	5.28	3.18
Sample Size	1	3	64.00	15	36	1	44	2
Statistical Week 24								
Mean Fork Length (cm)		61.13	53.46	79.52	71.61	89.00	83.74	86.50
Maximum		76.5	63.0	92.5	87.0	89.0	95.0	86.5
Minimum		45.0	44.5	64.5	58.5	89.0	75.0	86.5
Standard Deviation		9.62	4.25	7.13	6.81	--	5.30	--
Sample Size		8	46	29	37	1	41	1
Statistical Week 25								
Mean Fork Length (cm)		62.86	54.82	82.25	69.46	84.50	80.32	
Maximum		68.0	61.5	94.0	78.0	84.5	102.0	
Minimum		56.0	48.0	70.0	59.5	84.5	72.0	
Standard Deviation		4.04	4.27	7.12	5.70	--	7.95	
Sample Size		7	17	8	13	1	11	
Statistical Week 26								
Mean Fork Length (cm)		62.06	55.46	82.00	71.46		81.53	
Maximum		65.0	63.5	89.5	84.0		90.0	
Minimum		57.0	46.0	76.0	55.0		71.5	
Standard Deviation		2.88	4.40	4.31	7.47		6.02	
Sample Size		8	25	7	24		15	
Statistical Week 27								
Mean Fork Length (cm)		59.21	53.19	81.43	71.59		84.33	
Maximum		62.0	63.0	88.0	83.0		99.5	
Minimum		55.0	42.0	71.0	56.0		76.5	
Standard Deviation		2.60	5.61	4.72	6.80		4.58	
Sample Size		7	18	14	32		23	
Statistical Week 28								
Mean Fork Length (cm)	45.00	63.83	54.30	80.15	72.20		83.40	85.50
Maximum	45.0	72.0	65.5	89.5	86.5		93.0	85.5
Minimum	45.0	56.0	41.0	69.0	61.0		75.5	85.5
Standard Deviation	--	4.05	5.04	5.04	6.74		4.00	--
Sample Size	1	32	27	31	22		24	1
Statistical Week 29								
Mean Fork Length (cm)	44.50	62.68	51.31	79.00	69.61	84.00	80.63	
Maximum	48.5	69.0	58.5	88.0	84.0	86.0	98.0	
Minimum	40.5	56.0	37.5	71.5	57.0	82.0	61.5	
Standard Deviation	5.66	3.31	6.47	4.66	8.33	2.83	9.97	
Sample Size	2	20	8	21	14	2	8	
Statistical Week 30								
Mean Fork Length (cm)	40.00	63.04	50.75	80.32	71.04		87.00	
Maximum	40.0	70.0	51.0	91.0	85.0		92.0	
Minimum	40.0	56.0	50.5	73.5	60.5		80.0	
Standard Deviation	0.00	4.43	0.35	5.54	6.94		5.18	
Sample Size	2	13	2	11	12		4	
Statistical Week 31								
Mean Fork Length (cm)		62.29	54.00	73.63	72.00		89.00	
Maximum		67.0	64.0	79.0	72.0		89.0	
Minimum		50.0	44.5	68.5	72.0		89.0	
Standard Deviation		5.86	8.09	4.37	--		--	
Sample Size		7	4	4	1		1	
2013 Composite								
Mean Fork Length (cm)	**43.42**	**62.67**	**53.60**	**80.17**	**71.19**	**86.30**	**83.70**	
Maximum	**48.5**	**76.5**	**65.5**	**94.0**	**87.0**	**90.0**	**102.0**	
Minimum	**40.0**	**45.0**	**37.5**	**64.5**	**55.0**	**82.0**	**61.5**	
Standard Deviation	**3.73**	**4.61**	**4.54**	**5.92**	**6.55**	**3.27**	**5.70**	
Sample Size	**6**	**105**	**211**	**140**	**191**	**5**	**171**	

Table A4. Length-at-age estimates for Columbia Basin fall Chinook salmon sampled at Bonneville Dam in 2013.

Brood Year and	2011	2010		2009		2008		2007	
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
Statistical Week 31									
Mean Fork Length (cm)	41.00	65.00		79.50	77.00				
Maximum	41.0	65.0		92.0	77.0				
Minimum	41.0	65.0		67.0	77.0				
Standard Deviation	--	--		17.68	--				
Sample Size	1	1		2	1				
Statistical Week 32									
Mean Fork Length (cm)	54.50	62.36		75.06					
Maximum	54.5	77.0		79.5					
Minimum	54.5	47.5		68.5					
Standard Deviation	--	9.34		3.99					
Sample Size	1	11		8					
Statistical Week 33									
Mean Fork Length (cm)	44.50	64.79	61.50	77.47	70.00	95.00	83.75		
Maximum	49.5	77.5	61.5	88.0	73.0	101.5	87.0		
Minimum	40.5	46.0	61.5	56.5	63.0	90.5	80.5		
Standard Deviation	3.39	6.46	--	6.59	3.52	5.77	4.60		
Sample Size	5	29	1	34	6	3	2		
Statistical Week 34									
Mean Fork Length (cm)	45.57	65.21	51.17	78.67	71.50	85.00			
Maximum	53.0	73.0	54.0	88.0	72.0	89.0			
Minimum	37.5	52.0	46.0	62.0	71.0	80.0			
Standard Deviation	5.42	5.11	4.48	7.30	0.71	4.23			
Sample Size	7	19	3	23	2	5			
Statistical Week 35									
Mean Fork Length (cm)	46.11	63.74	56.50	77.09	80.50	93.00	75.00		86.00
Maximum	50.0	79.0	63.0	93.5	80.5	93.0	75.0		86.0
Minimum	41.0	52.5	47.0	56.0	80.5	93.0	75.0		86.0
Standard Deviation	2.93	5.32	5.16	5.91	--	--	--		--
Sample Size	9	35	7	58	1	1	1		1
Statistical Week 36									
Mean Fork Length (cm)	46.20	66.07	56.25	77.88		92.83	80.00		
Maximum	49.0	78.5	59.5	90.0		105.5	80.0		
Minimum	43.0	49.5	53.0	62.0		85.0	80.0		
Standard Deviation	2.59	5.17	4.60	6.51		11.07	--		
Sample Size	5	37	2	59		3	1		
Statistical Week 37									
Mean Fork Length (cm)	46.25	65.55		75.67	76.00	84.50			
Maximum	50.0	75.5		92.5	76.0	90.0			
Minimum	44.0	53.5		58.5	76.0	78.5			
Standard Deviation	2.04	4.49		5.12	--	5.77			
Sample Size	6	104		80	1	3			
Statistical Week 38									
Mean Fork Length (cm)	46.81	64.21		75.08		85.60			
Maximum	56.5	73.0		91.0		89.0			
Minimum	44.0	49.0		63.0		81.5			
Standard Deviation	4.15	4.67		5.09		3.03			
Sample Size	8	109		56		5			
Statistical Week 39									
Mean Fork Length (cm)	44.00	64.39	56.50	74.88	75.00	82.56	60.50	80.00	
Maximum	44.0	76.0	61.0	92.0	75.0	91.0	60.5	80.0	
Minimum	44.0	51.0	54.0	52.5	75.0	75.0	60.5	80.0	
Standard Deviation	--	5.01	3.91	6.20	--	4.69	--	--	
Sample Size	1	156	3	70	1	9	1	1	
Statistical Week 40									
Mean Fork Length (cm)	40.50	65.49	53.00	75.65	72.50	85.00		89.00	
Maximum	44.5	74.5	53.0	86.5	72.5	87.0		93.0	
Minimum	37.5	55.0	53.0	62.0	72.5	83.0		85.0	
Standard Deviation	3.61	4.54	--	5.24	--	2.83		5.66	
Sample Size	3	111	1	76	1	2		2	
Statistical Week 41									
Mean Fork Length (cm)	43.20	64.67		75.84	70.17	83.00			
Maximum	46.5	76.0		91.5	72.0	83.0			
Minimum	36.5	53.5		65.5	69.0	83.0			
Standard Deviation	4.09	4.68		4.92	1.61	--			
Sample Size	5	106		58	3	1			
Statistical Week 42									
Mean Fork Length (cm)		64.69	56.50	74.89		83.00			
Maximum		76.5	56.5	83.0		84.5			
Minimum		58.0	56.5	70.5		81.5			
Standard Deviation		4.82	--	3.62		2.12			
Sample Size		16	1	9		2			
2013 Composite									
Mean Fork Length (cm)	**45.42**	**64.80**	**55.67**	**76.15**	**72.16**	**86.03**	**76.60**	**86.00**	**86.00**
Maximum	**56.50**	**79.00**	**63.00**	**93.50**	**80.50**	**105.50**	**87.00**	**93.00**	**86.00**
Minimum	**36.50**	**46.00**	**46.00**	**52.50**	**63.00**	**75.00**	**60.50**	**80.00**	**86.00**
Standard Deviation	**3.96**	**4.96**	**4.61**	**5.80**	**3.87**	**6.17**	**9.96**	**6.56**	**--**
Sample Size	**51.00**	**734.00**	**18.00**	**533.00**	**16.00**	**34.00**	**5.00**	**3.00**	**1.00**

Table A5. Length-at-age estimates for Columbia Basin sockeye salmon sampled at Bonneville Dam in 2013.

Brood Year and	2010	2009		2008	
Age Class	1.1	1.2	2.1	1.3	2.2
Statistical Week 23					
Mean Fork Length (cm)		49.05		55.08	
Maximum		52.5		57.0	
Minimum		46.0		53.5	
Standard Deviation		2.10		1.43	
Sample Size		10		6	
Statistical Week 24					
Mean Fork Length (cm)	40.17	49.64		56.19	49.21
Maximum	42.5	55.0		60.0	52.5
Minimum	39.0	42.5		50.0	45.5
Standard Deviation	2.02	2.13		2.24	2.32
Sample Size	3	95		35	7
Statistical Week 25					
Mean Fork Length (cm)	37.50	49.88		56.78	50.67
Maximum	37.5	54.0		59.5	54.0
Minimum	37.5	40.0		52.0	47.5
Standard Deviation	--	2.17		1.81	2.36
Sample Size	1	107		25	6
Statistical Week 26					
Mean Fork Length (cm)	39.07	49.72		55.66	50.58
Maximum	44.0	55.0		63.0	55.0
Minimum	36.5	43.5		49.5	48.0
Standard Deviation	1.83	2.08		2.36	1.98
Sample Size	15	165		29	20
Statistical Week 27					
Mean Fork Length (cm)	38.42	49.38	40.00	55.07	50.00
Maximum	42.0	54.0	40.0	58.0	52.5
Minimum	36.0	44.0	40.0	51.5	46.0
Standard Deviation	1.46	2.30	--	2.17	3.50
Sample Size	18	50	1	7	3
Statistical Week 28					
Mean Fork Length (cm)	38.33	50.21	45.00	55.78	50.33
Maximum	47.0	54.5	45.0	64.0	53.0
Minimum	36.0	46.5	45.0	51.0	47.0
Standard Deviation	1.81	1.84	--	4.29	2.22
Sample Size	47	46	1	9	9
Statistical Week 29					
Mean Fork Length (cm)	38.02	49.17	42.00	54.63	49.00
Maximum	43.0	53.0	42.0	58.0	53.0
Minimum	36.0	45.0	42.0	49.5	45.0
Standard Deviation	1.67	2.64	--	3.64	4.00
Sample Size	33	6	1	4	3
Statistical Week 30					
Mean Fork Length (cm)	37.67	55.00			
Maximum	40.0	55.0			
Minimum	36.0	55.0			
Standard Deviation	1.37	--			
Sample Size	9	1			
Statistical Week 31					
Mean Fork Length (cm)	38.25	46.50			
Maximum	38.5	46.5			
Minimum	38.0	46.5			
Standard Deviation	0.35	--			
Sample Size	2	1			
Statistical Week 32					
Mean Fork Length (cm)	38.50				
Maximum	38.5				
Minimum	38.5				
Standard Deviation	--				
Sample Size	1				
2013 Composite					
Mean Fork Length (cm)	**38.34**	**49.74**	**42.33**	**55.97**	**50.21**
Maximum	**47.0**	**55.0**	**45.00**	**64.00**	**55.0**
Minimum	**36.0**	**40.0**	**40.00**	**49.50**	**45.0**
Standard Deviation	**1.71**	**2.14**	**2.52**	**2.42**	**2.29**
Sample Size	**129**	**481**	**3**	**115**	**48**

Table A6. Length-at-age estimates for Columbia Basin steelhead sampled at Bonneville Dam in 2013.

Ocean Age Class	Salt-Winters 1	2	3
Statistical Week 17			
Mean Fork Length (cm)	61.00	69.00	
Maximum	62.5	84.0	
Minimum	59.5	57.0	
Standard Deviation	2.12	9.78	
Sample Size	2	5	
Statistical Week 18			
Mean Fork Length (cm)		64.40	
Maximum		69.0	
Minimum		59.5	
Standard Deviation		4.17	
Sample Size		5	
Statistical Week 19			
Mean Fork Length (cm)	53.00	68.50	76.00
Maximum	53.0	73.0	76.0
Minimum	53.0	63.5	76.0
Standard Deviation	--	3.46	--
Sample Size	1	5	1
Statistical Week 20			
Mean Fork Length (cm)	66.00	68.42	81.00
Maximum	66.0	76.0	81.0
Minimum	66.0	59.0	81.0
Standard Deviation	--	6.23	--
Sample Size	1	6	1
Statistical Week 21			
Mean Fork Length (cm)		70.56	83.42
Maximum		76.5	89.0
Minimum		64.5	77.5
Standard Deviation		4.53	4.36
Sample Size		8	6
Statistical Week 22			
Mean Fork Length (cm)	50.00	64.94	74.00
Maximum	50.0	70.5	74.0
Minimum	50.0	58.0	74.0
Standard Deviation	--	3.72	--
Sample Size	1	9	1
Statistical Week 23			
Mean Fork Length (cm)	58.00	69.60	
Maximum	63.0	74.5	
Minimum	53.0	62.5	
Standard Deviation	7.07	4.92	
Sample Size	2	5	
Statistical Week 24			
Mean Fork Length (cm)		70.83	78.00
Maximum		74.5	79.5
Minimum		67.0	76.5
Standard Deviation		3.75	2.12
Sample Size		3	2
Statistical Week 25			
Mean Fork Length (cm)	52.33	70.63	
Maximum	53.0	74.5	
Minimum	51.0	68.5	
Standard Deviation	1.15	2.84	
Sample Size	3	4	

Ocean Age Class	Salt-Winters 1	2	3
Statistical Week 26			
Mean Fork Length (cm)	52.42	69.25	
Maximum	55.5	73.0	
Minimum	51.0	65.5	
Standard Deviation	1.72	5.30	
Sample Size	6	2	
Statistical Week 27			
Mean Fork Length (cm)	56.40	68.25	
Maximum	64.5	69.5	
Minimum	53.0	67.0	
Standard Deviation	4.79	1.77	
Sample Size	5	2	
Statistical Week 28			
Mean Fork Length (cm)	54.47	67.33	
Maximum	60.0	77.0	
Minimum	50.5	60.0	
Standard Deviation	2.17	3.59	
Sample Size	31	18	
Statistical Week 29			
Mean Fork Length (cm)	55.83	66.65	
Maximum	66.0	73.0	
Minimum	49.0	61.0	
Standard Deviation	2.77	2.89	
Sample Size	126	44	
Statistical Week 30			
Mean Fork Length (cm)	55.63	67.00	
Maximum	63.0	78.0	
Minimum	50.5	59.5	
Standard Deviation	2.51	3.86	
Sample Size	136	38	
Statistical Week 31			
Mean Fork Length (cm)	55.70	67.98	
Maximum	63.0	78.0	
Minimum	51.0	61.5	
Standard Deviation	2.78	3.80	
Sample Size	78	23	
Statistical Week 32			
Mean Fork Length (cm)	56.18	67.21	
Maximum	63.5	70.5	
Minimum	52.0	64.0	
Standard Deviation	2.56	2.55	
Sample Size	71	14	
Statistical Week 33			
Mean Fork Length (cm)	56.41	67.78	
Maximum	64.5	75.0	
Minimum	50.0	60.0	
Standard Deviation	2.52	3.27	
Sample Size	119	37	
Statistical Week 34			
Mean Fork Length (cm)	56.57	69.75	
Maximum	63.0	75.5	
Minimum	51.5	63.0	
Standard Deviation	2.51	3.44	
Sample Size	48	10	

Ocean Age Class	Salt-Winters 1	2	3
Statistical Week 35			
Mean Fork Length (cm)	57.28	70.56	
Maximum	65.0	82.0	
Minimum	49.5	60.0	
Standard Deviation	3.18	6.07	
Sample Size	70	36	
Statistical Week 36			
Mean Fork Length (cm)	57.18	68.31	
Maximum	60.0	72.0	
Minimum	54.0	64.5	
Standard Deviation	1.60	3.05	
Sample Size	20	8	
Statistical Week 37			
Mean Fork Length (cm)	60.75	71.94	
Maximum	64.5	81.0	
Minimum	58.5	65.5	
Standard Deviation	2.30	5.59	
Sample Size	6	8	
Statistical Week 38			
Mean Fork Length (cm)	59.21	76.37	85.00
Maximum	66.5	87.0	85.0
Minimum	54.0	64.0	85.0
Standard Deviation	3.79	6.43	--
Sample Size	24	30	1
Statistical Week 39			
Mean Fork Length (cm)	59.53	75.58	
Maximum	68.5	87.5	
Minimum	52.0	63.5	
Standard Deviation	4.72	6.38	
Sample Size	33	26	
Statistical Week 40			
Mean Fork Length (cm)	59.42	76.86	
Maximum	64.5	88.0	
Minimum	53.0	61.5	
Standard Deviation	3.55	6.81	
Sample Size	19	33	
Statistical Week 41			
Mean Fork Length (cm)	62.59	79.48	86.50
Maximum	69.0	86.5	86.5
Minimum	55.5	71.0	86.5
Standard Deviation	4.25	4.72	--
Sample Size	16	30	1
Statistical Week 42			
Mean Fork Length (cm)	61.00	79.06	
Maximum	66.5	83.5	
Minimum	55.5	70.5	
Standard Deviation	7.78	4.12	
Sample Size	2	8	
2013 Composite			
Mean Fork Length (cm)	56.54	70.88	81.46
Maximum	69.0	88.0	89.0
Minimum	49.0	57.0	74.0
Standard Deviation	3.26	6.51	4.75
Sample Size	820	417	13